

Case Report

Incidences of Frostbite in Arthroscopic Knee Surgery Postoperative Cryotherapy Rehabilitation

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Abstract: A retrospective study of 4 cases of frostbite was undertaken to examine causes and to identify related contributory behaviors and circumstances. These patients underwent various surgical interventions before the onset of frostbite during similar postoperative care regimens. Surgical procedures included some of the following in each patient: lateral retinacular release, vastus medialis oblique muscle advancement, partial medial meniscectomy, chondromalacia patella, trochlea, medial and lateral femoral condyle debridement, lateral retinaculum release, and excision of medial plica. The mechanism of onset, development, and sites of frostbite were uniform in all patients. In every case, the sites were located in the area on top of the patella including some adjacent regions depending on the size of each injury. Frostbite locations were correlated with the part of the cryotherapy cold cuff device located on top of the patellar region. This cuff portion was originally designed to accommodate surgical trauma induced during autogenous bone-tendon-bone graft harvest in anterior cruciate ligament reconstruction surgery. Locating cryotherapy over this region assisted in minimizing pain and effusion for patients subsequent to distal patella bone plug harvest trauma. However, the requirement for use of the pad in the patella area for patients not undergoing anterior cruciate ligament reconstruction with autograft was found to be unnecessary and was the primary cause of frostbite in the cases presented here. **Key Words:** Arthroscopic knee surgery—Frostbite—Rehabilitation—Cryotherapy.

Ice, or other applications of cryotherapy, has been recognized as one of the least expensive and widely used therapeutic modalities in the management of acute musculoskeletal injuries.¹ The confusion surrounding cryotherapy is almost as extensive as its popularity, with different opinions concerning its theoretical base, techniques of application, and the physiologic responses of the body to its application. The

use of cryotherapy for postoperative pain control and effusion reduction is not without risk. The onset and development of frostbite can be a significant complication. The complications of frostbite can have greater impact on the postoperative recovery than the original surgery itself. Patient selection, education, and cooperation are critical in the success of this therapy. The specific devices used can be even more important, as we will show in this report.

There have been reports of various studies on use of cryotherapy to reduce postoperative swelling and pain. The use of cryotherapy frequently results in the reduction of analgesic medication use after shoulder and foot surgery, knee arthroscopy, and knee arthroplasties. Ice packs or cryotherapy are generally more effective in terms of depth of penetration than other superficial thermal modalities. Effectiveness is related to appropriate matching of surface area required to the desired reduction in tissue temperature over time. In-

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tramuscular temperatures can actually be reduced by 3°C to 7°C. These temperature reductions are helpful in reducing local metabolism in addition to reducing swelling and pain.

The analgesic effects of cold result from a decreased nerve conduction velocity along pain fibers and a reduction of the muscle spindle activity responsible for mediating local muscle tone.² It is usually most effective in the acute phase of treatment, although the patient can use it after physical therapy or the home exercise program to reduce pain and inflammation. Typical use includes ice applied over an area for 15 to 20 minutes, 3 to 4 times a day initially, and then on an as-needed basis thereafter. Indications and contraindications for use are detailed in Case 1.

Recent advances in technology have produced several new cryotherapy modalities. Gravity-fed ice water systems and subsequent electric-motor driven continuous cold flow devices have become prevalent cryotherapy-delivery methods in recent years. Ice-cooled water stored in a thermos uses gravity feed to deliver cold water to custom contoured bladders that match joint physiology. These bladders have a continuous loop tubing design with inflow and outflow connections that, by raising and lowering the thermos in gravity fed systems, recycles water warmed from contact with the joint surface area back into the thermos to be re-cooled and replaced with cooled water back into the bladder. The temperature control of this delivered water is dependent on the initial ratio of ice to water, ambient air temperature, frequency of the gravity feed cycle, and size and heat-generating capacity of the surface and subsurface area being cooled. There is an inverse relationship between time and water temperature that necessitates ice and water maintenance at 1- to 8-hour intervals to maintain consistent cold temperatures over time.

Continuous-flow, temperature-adjustable, cold-water cryotherapy devices have been used recently with increased frequency and become more prevalent compared with gravity feed systems. Their use coincides with comments by patients and physicians who have expressed reservations about other cryotherapy-delivery methods. Typical complaints include issues of inconvenience; ice, water, and temperature maintenance, gravity feed requirements, or the necessary refreezing of gel packs.

A distinct advantage of the continuous-flow cryotherapy delivery system is the ability to adjust temperature setting. Temperature regulation with earlier and more primitive cold-therapy technology permitted only casual control by either limiting or adding ice,



FIGURE 1. DonJoy Iceman continuous cold flow thermos with accompanying knee pad.

including an insulating layer between the bladder or gel pack and the skin, or manual removal and reapplication. Limitations of temperature regulation can impose significant issues for patients with multiple

postoperative care conditions. Cryotherapy use must be integrated with other postoperative requirements such as pain medication use and management of their side effects, continuous passive motion therapy, other physical therapy, dressing changes, bracing and crutches, and transportation to and from postoperative appointments.

Temperature adjustment permits various temperature settings to be selected. Generally, warmer settings are used with longer cryotherapy cycles. The ability to control the water temperature and take advantage of longer cryotherapy cycle reduces inconvenience and maintains a more even tissue temperature.

The system that was used in the present report is an Iceman Model 1100 Cold Therapy unit (DJ Orthopedics, Vista, CA) along with a knee cuff that provides complete coverage of the anterior, medial, and lateral aspect of the knee with a specific extension of the cooling coils to cool the patella directly (Fig 1). It provides up to 7 hours of continuous cold therapy for a variety of indications. Using a semiclosed loop system, the Iceman maintains constant temperatures related to the temperature selected on the control.

Patients were instructed to use the device in accordance with the manufacturer's instructions and to never put the cuff in direct contact with the skin. All patients complied with these instructions and restrictions. The amount of time per day the devices were used varied by patient. The vascularity and tissue depth underlying the skin covering the patella are less than in other areas of the knee. Accordingly, cooling of the skin overlying the patella is more rapid and profound than other areas of skin about the knee.

METHODS

The cold cuff that was used in this instance was a continuous cold flow thermal therapy apparatus for applying temperature-controlled therapy to a site on the body. It consists of a therapy pad for applying a selected therapy temperature to the therapy site; a recirculating fluid loop, including a fluid channel defined by the therapy pad; a thermal reservoir; a heat-exchanger coupling in the thermal reservoir with the recirculating fluid loop, the heat exchanger including a pump for circulating fluid through the recirculating fluid loop; and a control mechanism coupled to the heat exchanger for enabling adjustable control of therapy temperature. The heat exchanger selectively mixes fluid recirculating in the fluid loop with fluid from the thermal reservoir in an adjustable mixing

ratio to achieve the selected therapy temperature at the therapy site.

RESULTS

Frostbite complication cases descriptions and results:

Case 1

Date of surgery: February 5, 2002.

48-year-old woman

Left knee

Surgery performed: chondromalacia patellar debridement, lateral retinacular release muscle advancement.



FIGURE 2. Case 1: Frostbite onset 20 days postoperatively with initial scabbing.

Date	Postoperative Visit	Findings
2/11/02	6 days	No symptoms, no bruising, didn't do exercises fully.
2/14	9 days	Hot knee, poor rehab or possible infection noted.
2/18	13 days	Purple blistered dry area.

Date	Postoperative Visit	Findings
2/22	18 days	Increasing discoloration.
2/25	20 days	Frostbite present; photographs taken.
3/7	30 days	Frostbite healing, not infected, no new blisters, blackened dry scab.
3/21	44 days	Frostbite resolving no evidence of infection.
4/18	2.5 months	Scab separating, yellowish fluid present at border of scab and skin separation (Fig 3).
5/13	3.5 months	Frostbite ROM 2° to 110°, 0° to 145°.
6/6	4 months	Wound size of dime with serous drainage, purulent base full-thickness skin lesions (Fig 4).
7/11	5 months	Wound closing but still painful around lesion.
9/19	7.5 months	Wound resolved, not pliable.
12/2	10 months	Skin not pliable. See Figs 2-4.



FIGURE 3. Frostbite scab separating 2.5 months postoperatively, yellowish fluid present at border of scab and skin separation.



FIGURE 4. Frostbite wound 4 months postoperatively. Remnant scabbing about size of dime with serous drainage, purulent base, and full-thickness skin lesions.

Case 2

Date of surgery: February 12, 2002

53-year-old man

Left knee

Surgery performed: partial medial meniscectomy, patellar chondromalacia, patellar medial femoral condyle debridement.

Note that the patient lives approximately 55 miles from the office. One day postoperative and 2 weeks postoperative interval directed by surgeon (Fig 5).

Date	Postoperative Visit	Findings
2/1	1 day	
2/26	14 days	Possible frostbite, no symptoms, photograph taken, 1 × 2 cm area.
3/7	23 days	Frostbite resolving.
5/7	3 months	Intermittent tightening during flexion ROM -1°, -3° to 135°.
7/8	5 months	Frostbite not mentioned, ROM -2° to 130°/140°.
4/30/04	2 years 2 mo	Frostbite not mentioned.



FIGURE 5. Case 2: Frostbite 14 days postoperatively. No accompanying symptoms, scab area approximately 1 × 2 cm.

Case 3

Date of surgery: February 12, 2002

48-year-old woman

Left knee

Surgery performed: lateral retinaculum release, chondromalacia lateral femoral condyle, medial femoral condyle and patellar debridement, excision of medial plica.

Date	Postoperative Visit	Findings
2/13	1 day	No symptoms
2/22	10 days	Patient stated that the knee cryotherapy device caused a burning sensation, swelling, ecchymosis, and erythema over the patella. Patient told to discontinue cold pack and limit flexion.
2/28	16 days	Second-degree frostbite present; stated area slightly smaller, patient reports no problems with mobility (Fig 6).
3/7	23 days	Frostbite slowly resolving no evidence of infection.
3/18	34 days	Frostbite lesion resolving, knee function improving.

Date	Postoperative Visit	Findings
4/4	2 months	Black scab 4.0 × 4.5 cm, decreasing, new pink skin at black scab area, no active seepage, no sign of infection, difficulty with stairs.
5/16	3 months	Two-cm diameter scab remaining, ROM ext, flexion 2° different 134°/136°.
6/3	4 months	Small scab remnant.
7/1	4.5 months	Small site left, -2° to 135° bilaterally.
10/27/03		Resultant thin skin at frostbite site (Fig 6).



FIGURE 6. Case 3: Frostbite 16 days postoperatively, second-degree present.

Case 4

Date of surgery: February 25, 2003

37-year-old woman

Surgery performed: partial meniscectomy, debridement of trochlea, lateral retinaculum release.

Date	Postoperative Visit	Findings
2/26	1 day	Dressing change, moderate swelling.
3/10	13 days	Telephone contact: swelling gone, icing for aches on or after work, flexion good, full extension difficult, morning stiffness decreasing with use.
3/11	14 days	Telephone contact—knee feels good then knee feels sore, ibuprofen 800 mg 3 times daily.
4/3	35 days	Telephone contact: patient states at 3 weeks noted an area approximately 4 × 3 inches, right knee lateral, of scabbing, fluid tissue. Painful like abrasion. States area now 1½ × 2 inches, clean and dry. No fever. Currently using water, soap, Neosporin, and H ₂ O ₂ .
4/10	42 days	Patient has open lesion anterior to patella ROM equal, extension 120°/130° flexion. Triple antibiotics use prescription.
5/20	3 months	Telephone contact with patient. Had right knee debridement of frostbite area in April. Area appears closing slowly.

None of the patients required hospitalization and their frostbite injuries resolved over time. The incidence of frostbite in these patients did contribute to additional time and effort to rehabilitate from their surgery and is a complication worth avoiding.

DISCUSSION

Although the instructions for the use of cryotherapy are not complicated, they are given in conjunction with all other patient training information for postoperative self-management in surgical outpatient settings. There is the potential for misunderstandings about the relationship between onset of symptoms, how they relate to potential complications, and that appropriate interventions can only be initiated with communication by the patient with nursing staff. The possibility of frostbite and the awareness of potentially conflicting symptom reporting by patients to nurses has been noted in training implemented for the nursing staff. Additionally, this information has been incorporated into the patient education as part of their



FIGURE 7. Modified cryotherapy cuff without any coverage over the patellar area.

rehabilitation safety training. All directions supplied by the manufacturer were followed.

The cuff used by the patients has a section over the patella that is designed to contend with inflammation associated with patellar tendon harvesting. When used in conjunction with the continuous cold flow motor-powered thermos, the area affected in the cases presented here is susceptible to frostbite because of the lack of sufficient insulative characteristics of the skin in and around the patella. Since the occurrence of these frostbite cases, the manufacturer of the cryotherapy device that caused the frostbite has since designed and manufactured a modified cryotherapy cuff without any coverage over the patellar area (Fig 7).

It can be used in conjunction with the same continuous cold flow thermos system as the full-cover cuff but with a significantly lower risk of frostbite in the patellar area. In the 2 years that we have been using the new design of the cuff, there have been no incidences of frostbite in any of over 1,500 uses of the newly designed device. The device providing direct cooling of the patellar area should be used with extreme caution because of the clear risk of frostbite.

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